Bunker Silage Storage Leachate and Runoff Management

Eric Cooley, UW Discovery Farms

Aaron Wunderlin, UW Discovery Farms

Dr. Becky Larson, Assistant Professor UW-Madison

Mike Holly, PhD Student UW-Madison

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Feed Storage Leachate Studies

UW Biological Systems Engineering (Dr. Rebecca Larson and Michael Holly)

- 3 locations: Arlington Agricultural Research Station, Dairy Forage Research Center and private dairy bunker
- Total combined runoff monitored
- Monitored October 2011 to October 2012 (no wintertime monitoring)
- Discrete sample protocol to characterize individual storms

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- 3 locations: 3 private dairy bunkers
- Both leachate collection system and overflow to VTA monitored separately
- Monitored October 2012 to December 2014 (with wintertime monitoring)
- Discrete and composite sample protocol to focus on annual loading trends

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Leachate

(Silage) leachate – liquid produced in feed storage systems from compaction and ensilage of harvested crops.

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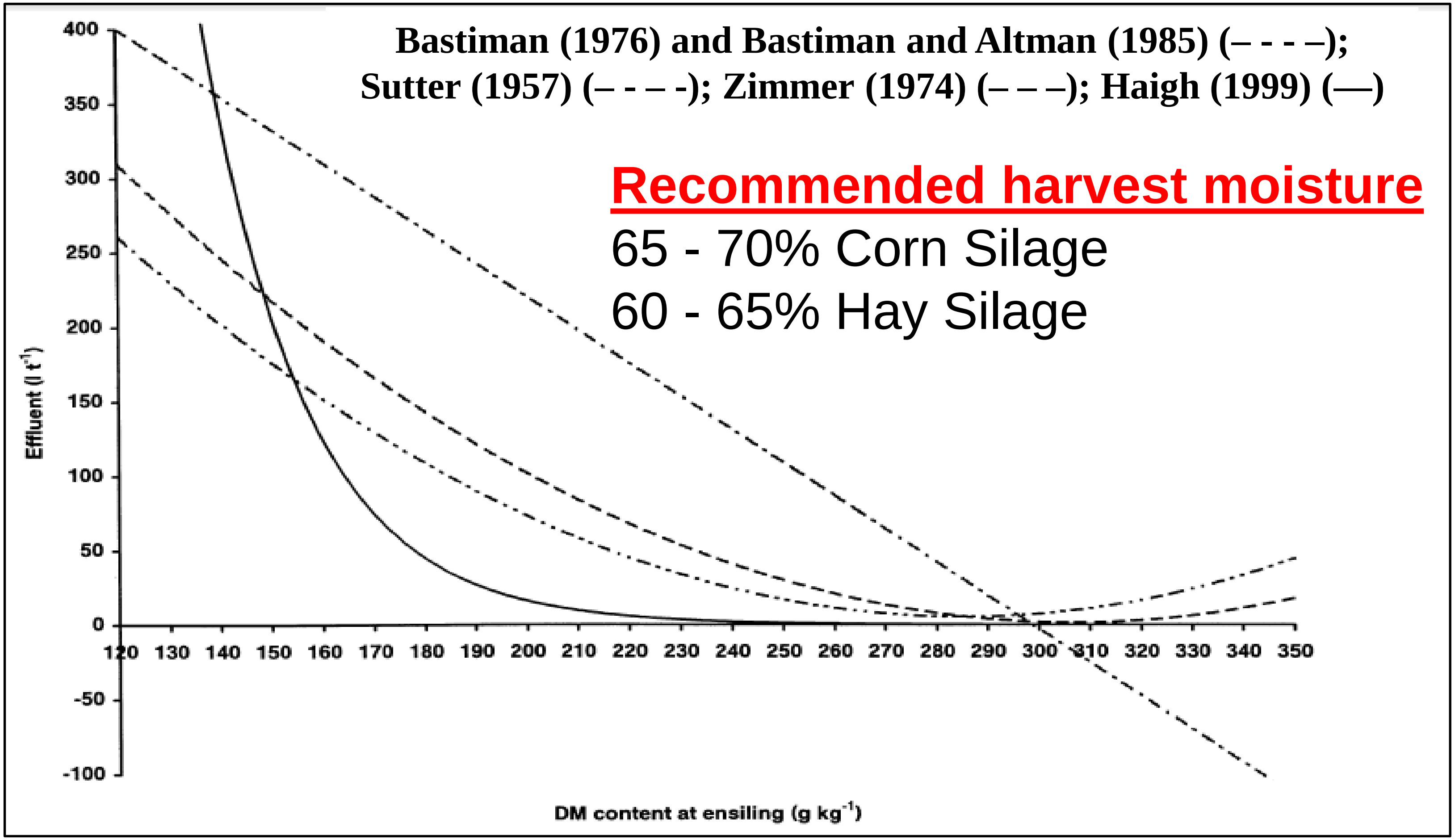
Leachate Production Based on Dry Matter Content



Recommended harvest moisture

65 - 70% Corn Silage

60 - 65% Hay Silage

(Haigh, 1999)

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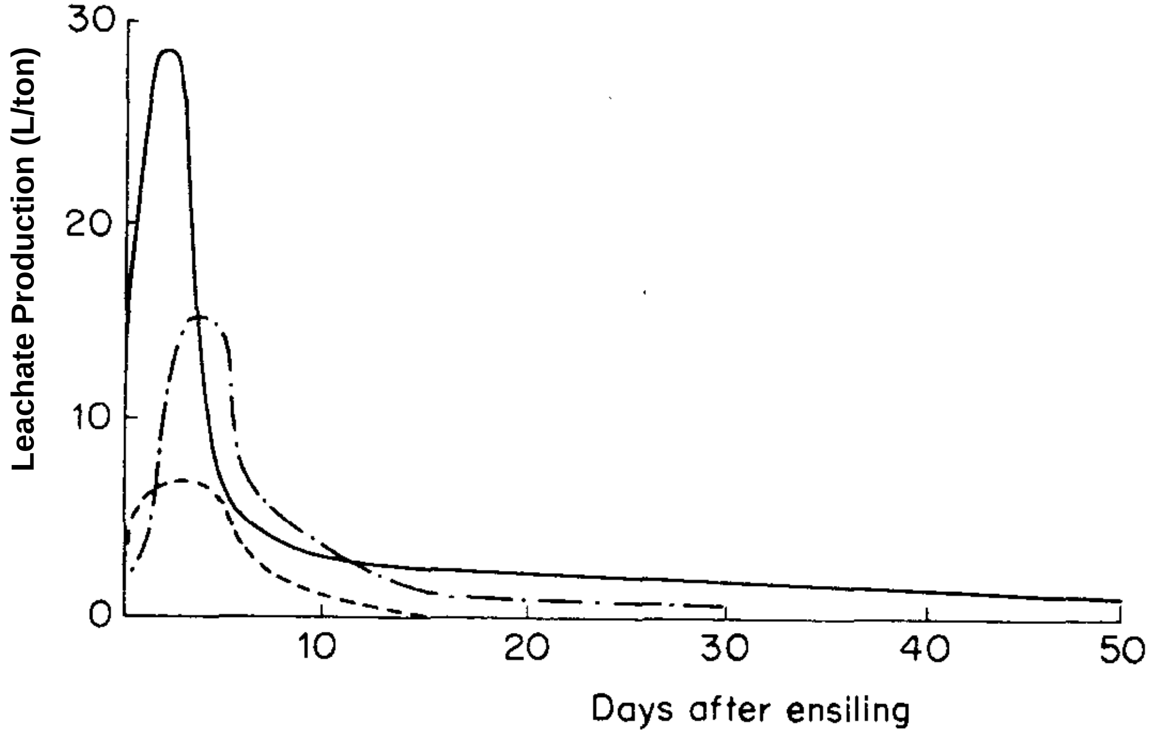
Timing of Leachate Production



Patterns of effluent production.[49] Silage DM content (g kg^{-1}): ———— 158; —·—·—· 182; ——————— 219

Mc Donald 1981, Referencing Bastiman 1976

Runoff

<u>(Feed storage) runoff</u> – precipitation induced flow from feed storage systems as a result of rain/snowmelt contacting stored feed, litter, and spoilage piles; essentially “diluted leachate”.

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What is in leachate and runoff?

Constituent	Liquid Dairy Manure[1]	Leachate[2]	Feed Storage Runoff
Dry Matter	5%	5% (2-10%)	0 - 5%
Total N (mg/L)	2,600	1,500-4,400	20 – 1,400
P (mg/L)	1,100	300-600	8 - 660
K (mg/L)	2,500	3,400-5,200	n/a
pH	7.4	3.6-5.5	4 - 7
BOD (mg/L)	5,000-10,000	12,000-90,000	500 - 61,000

[1]Clarke and Stone 1995
[2]Cornell 1994

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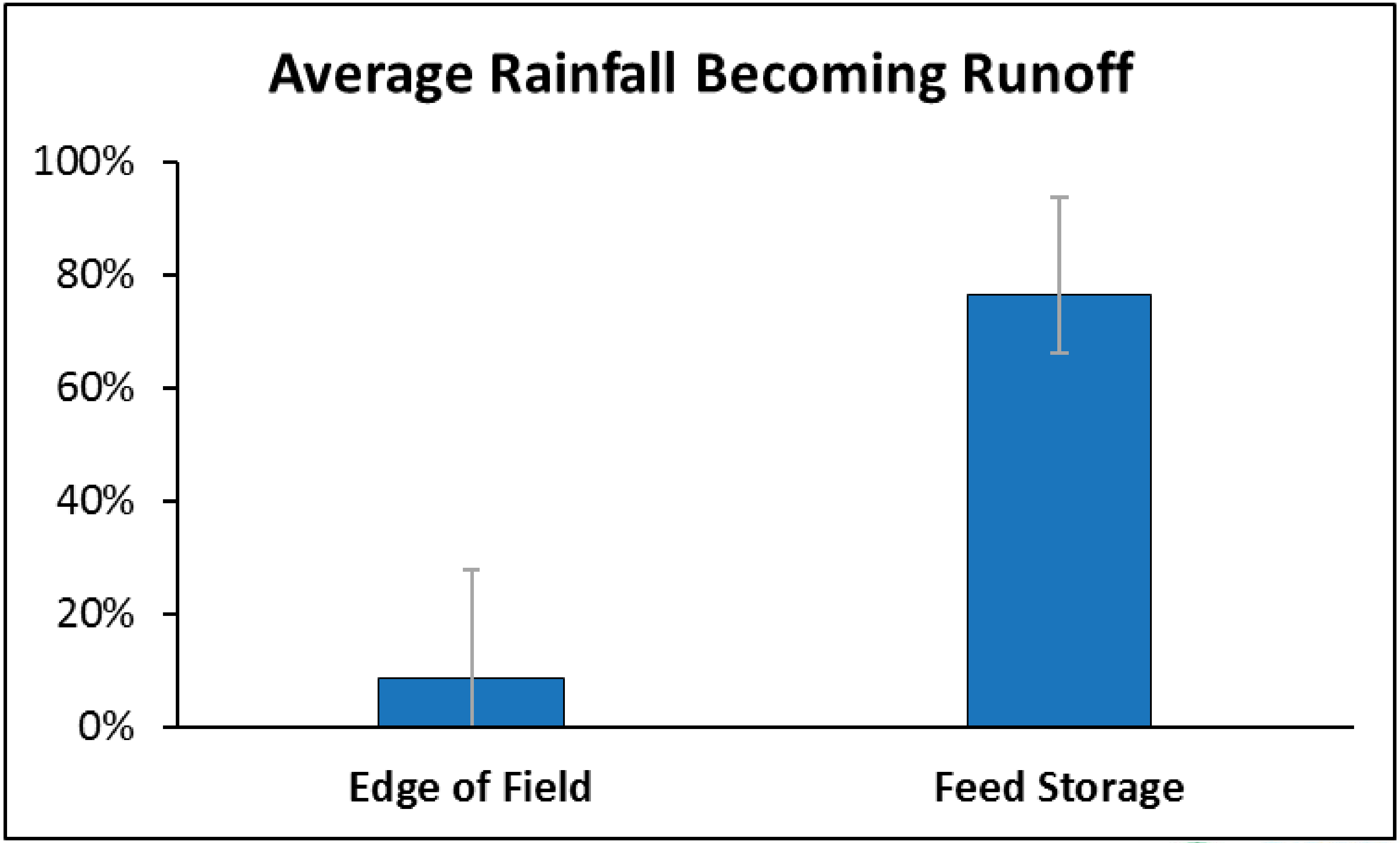
Edge of Field vs Feed Storage Water Comparison



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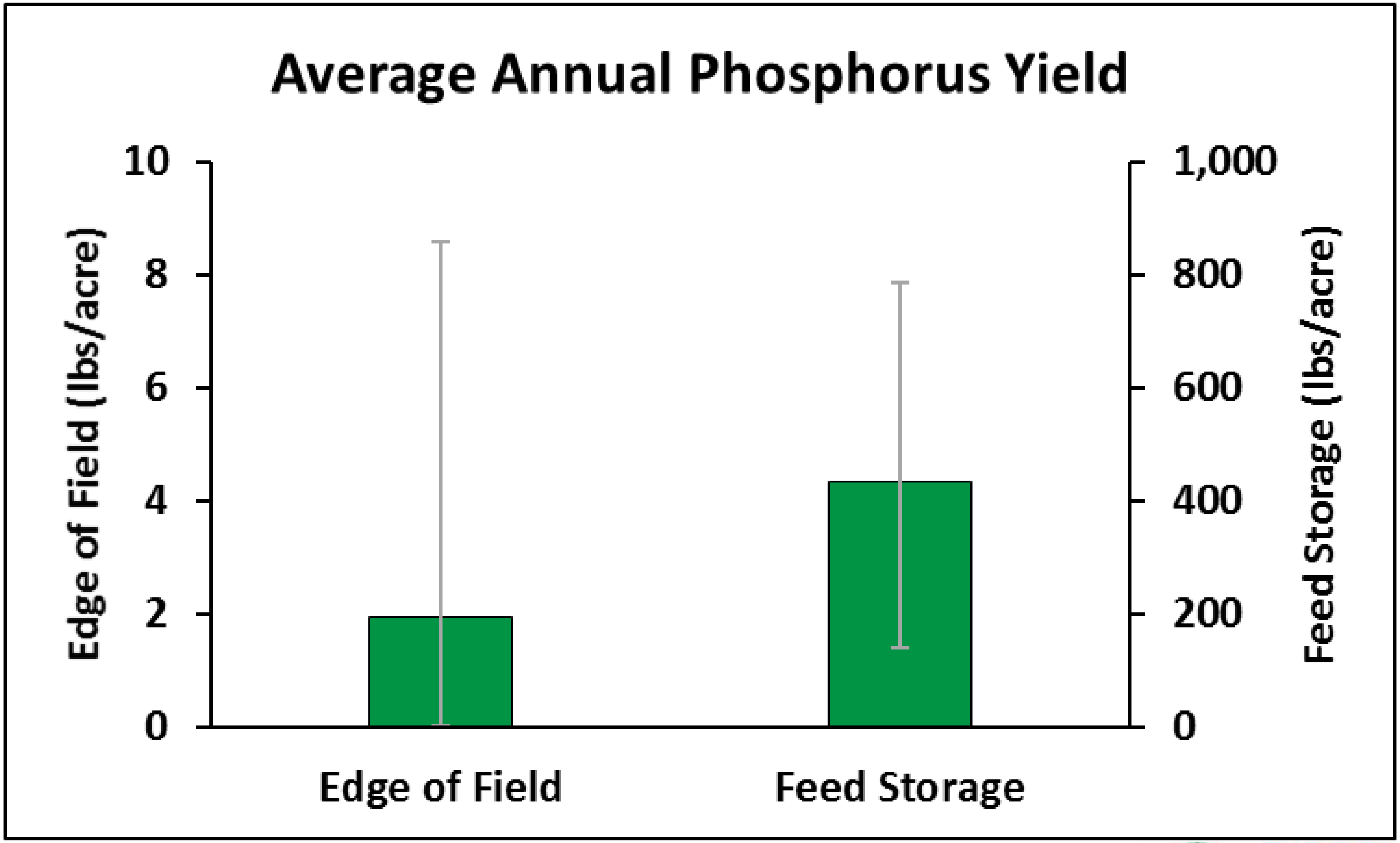
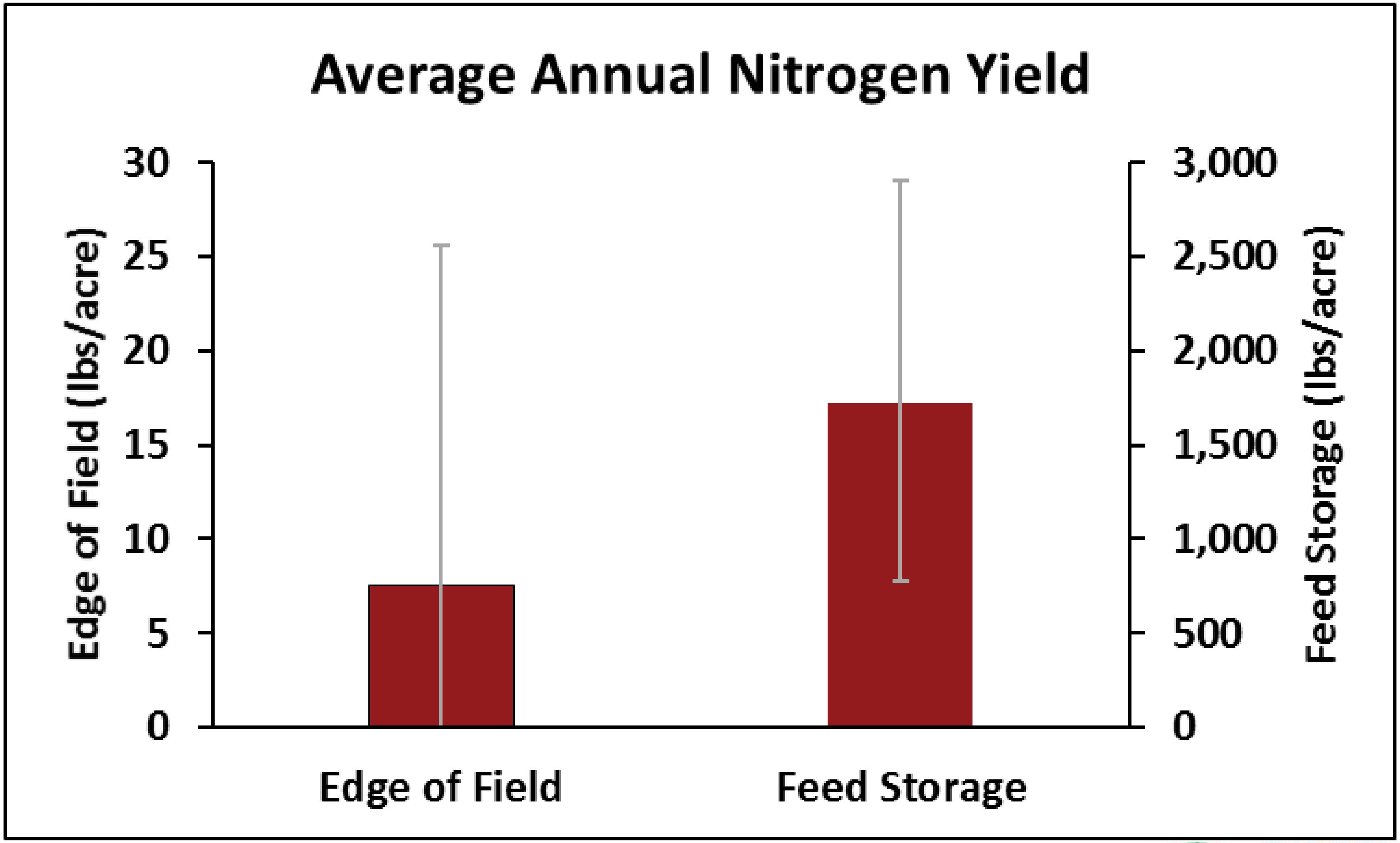
Edge of Field vs Feed Storage Phosphorus Comparison



Edge of Field vs Feed Storage Nitrogen Comparison



Collection System Design

Current System Design (NRCS Code 629)

- Capture all leachate
- Capture 1st flush runoff
  - Engineered based on urban runoff system design
  - Percent collected based on feed storage area and VTA sizing
- 25-year/24-hour storm diversion

Future system design

- EPA has expressed concerns to DNR about current operation/design of VTAs meeting WPDES "no discharge" requirements
- More efficient alternative systems?

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Collection System Design

Objectives

- Comply with “no discharge” requirement while minimizing storage and handling costs

- Total containment up to a 25-year, 24-hour storm event

vs.

- Collect high concentration liquid
- Modify VTA design/operation of VTA, if possible

Collection Designs are Numerous

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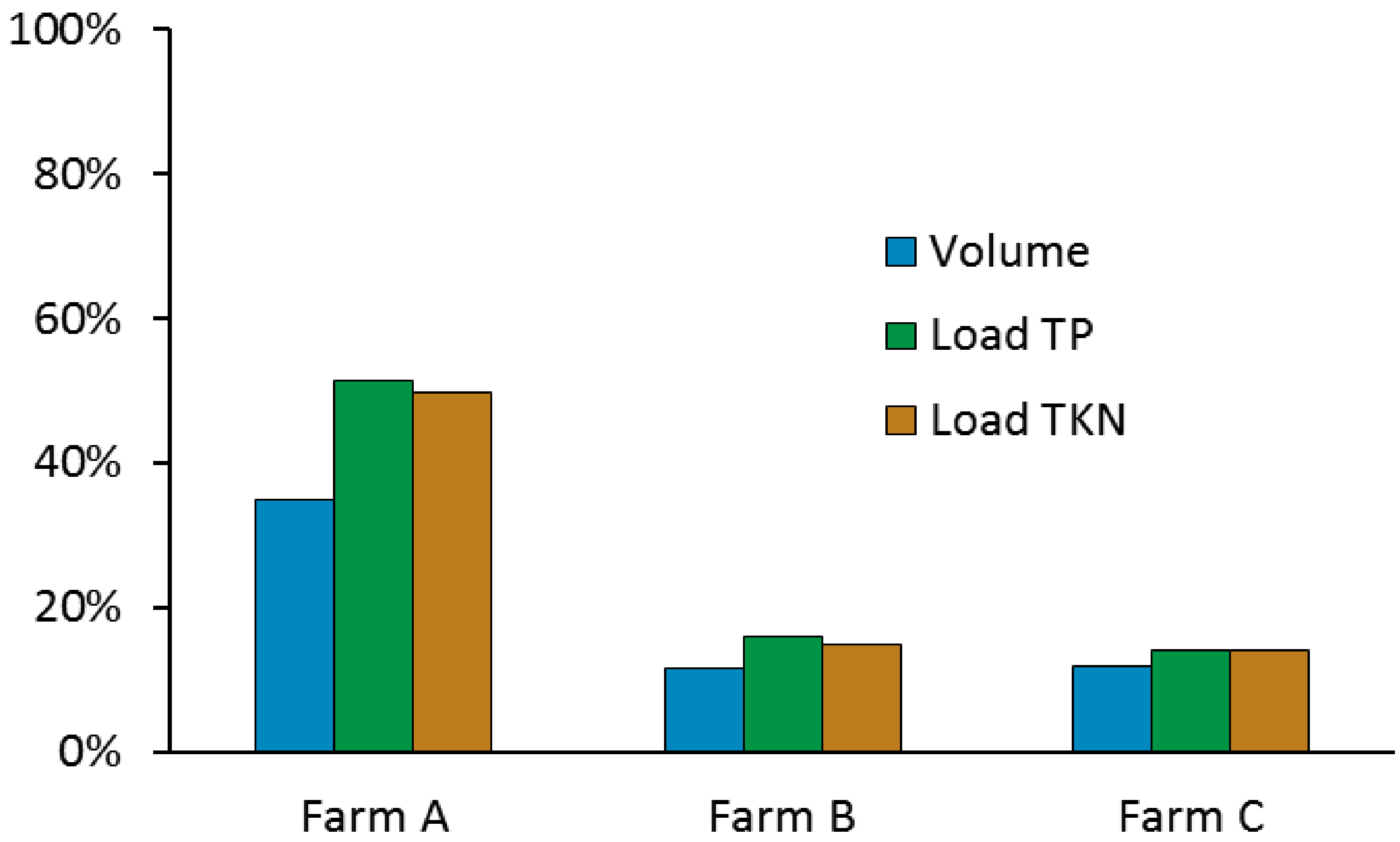
Nutrient Collection



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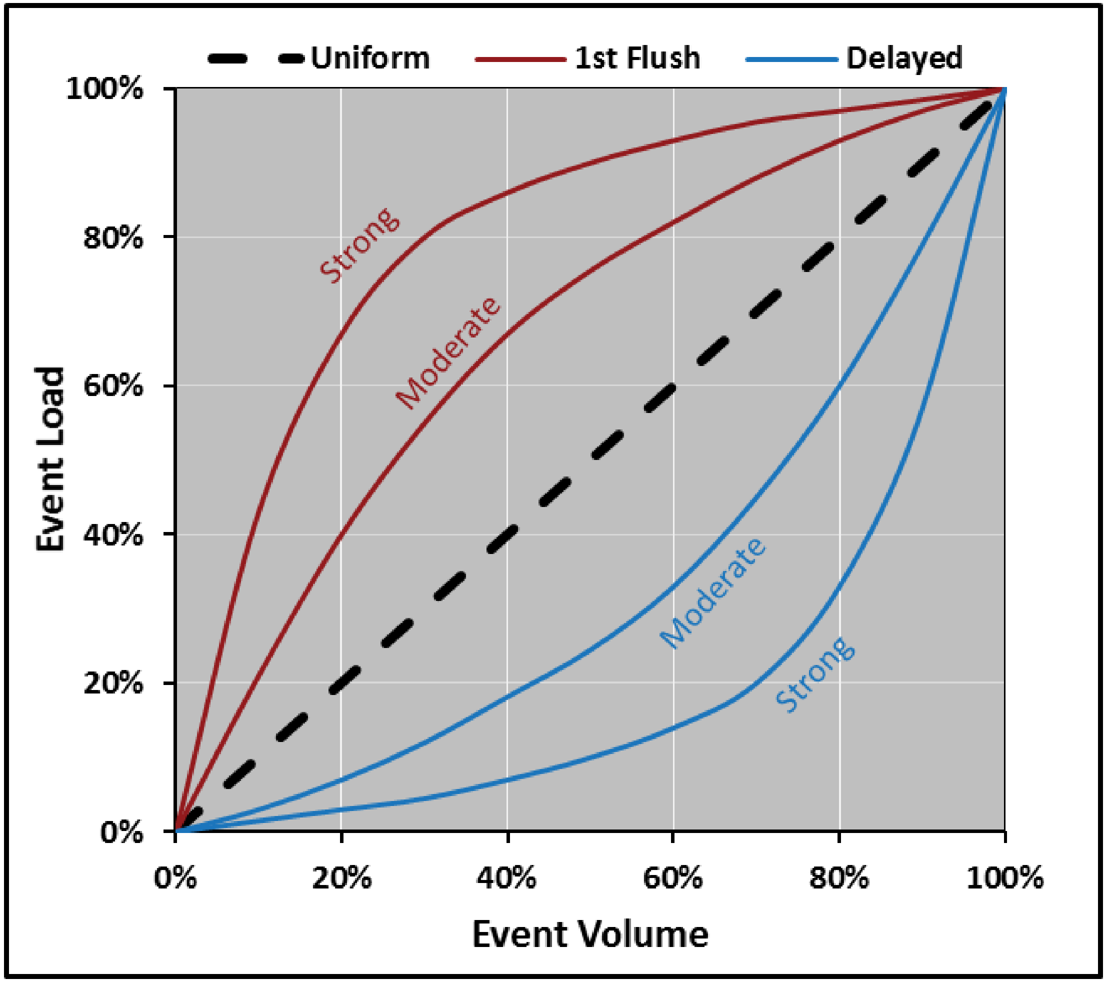
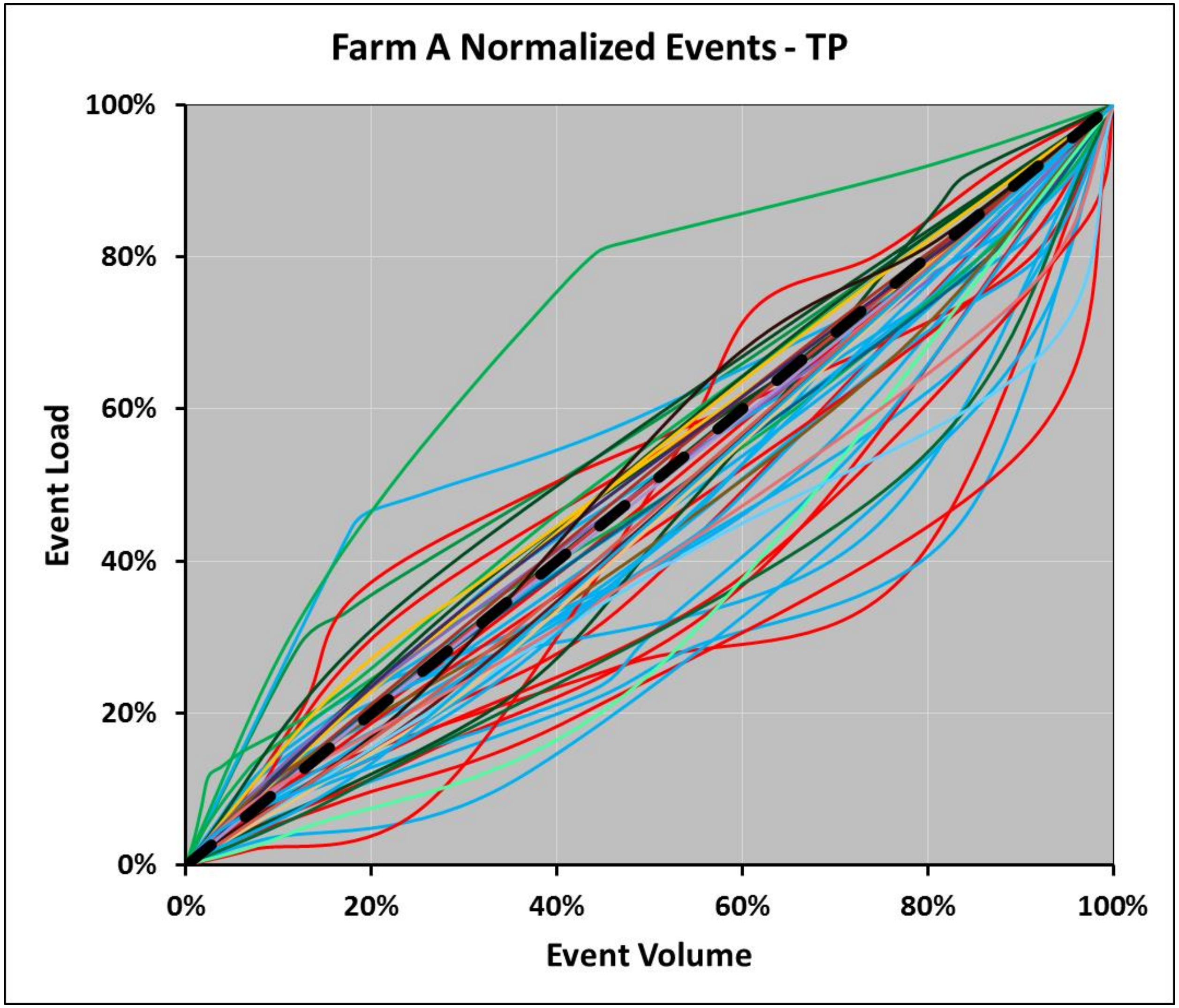
Does a First-Flush Exist?



(Taebi & Droste, 2004)

Normalized Phosphorus Data



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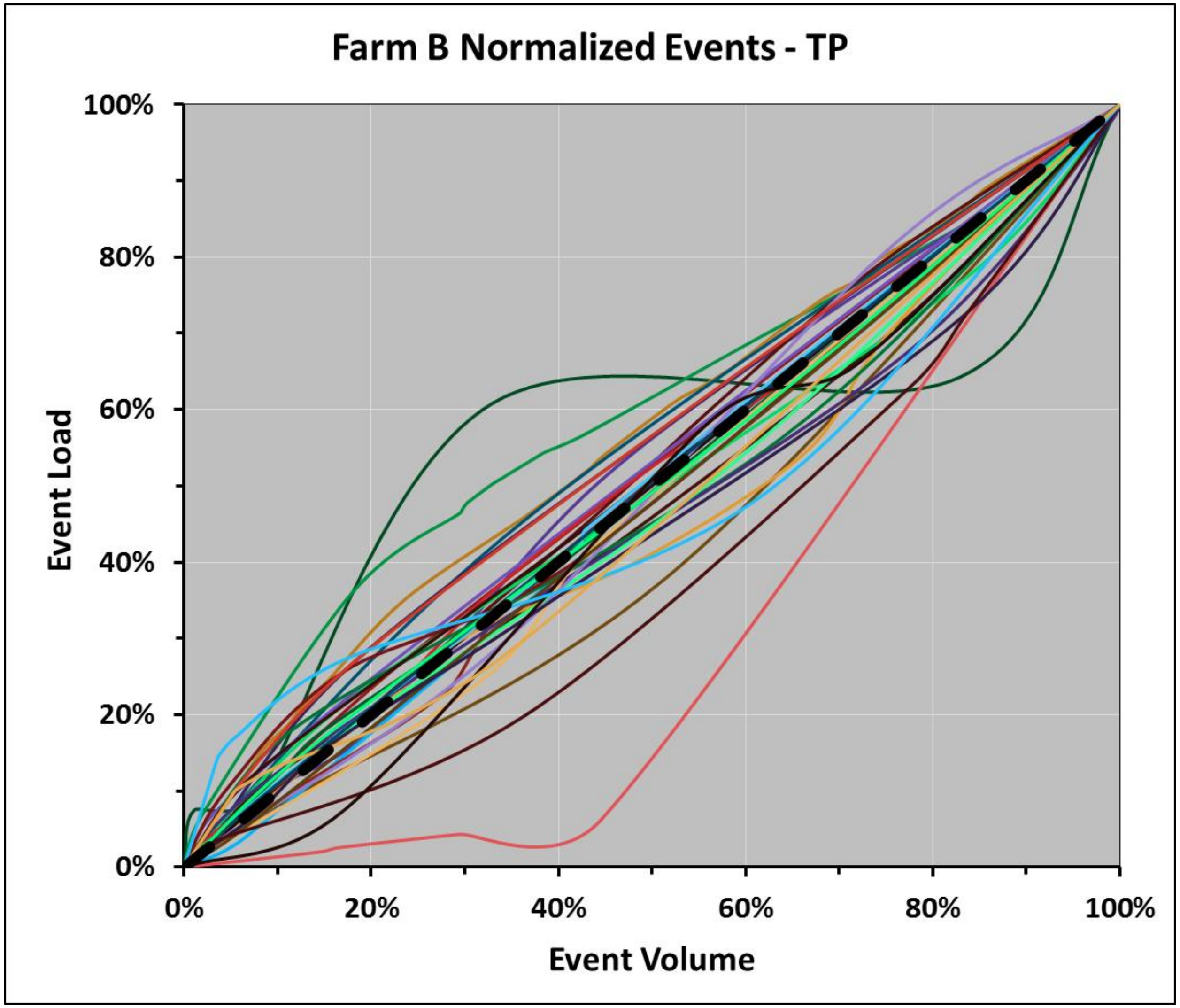
Normalized Phosphorus Data



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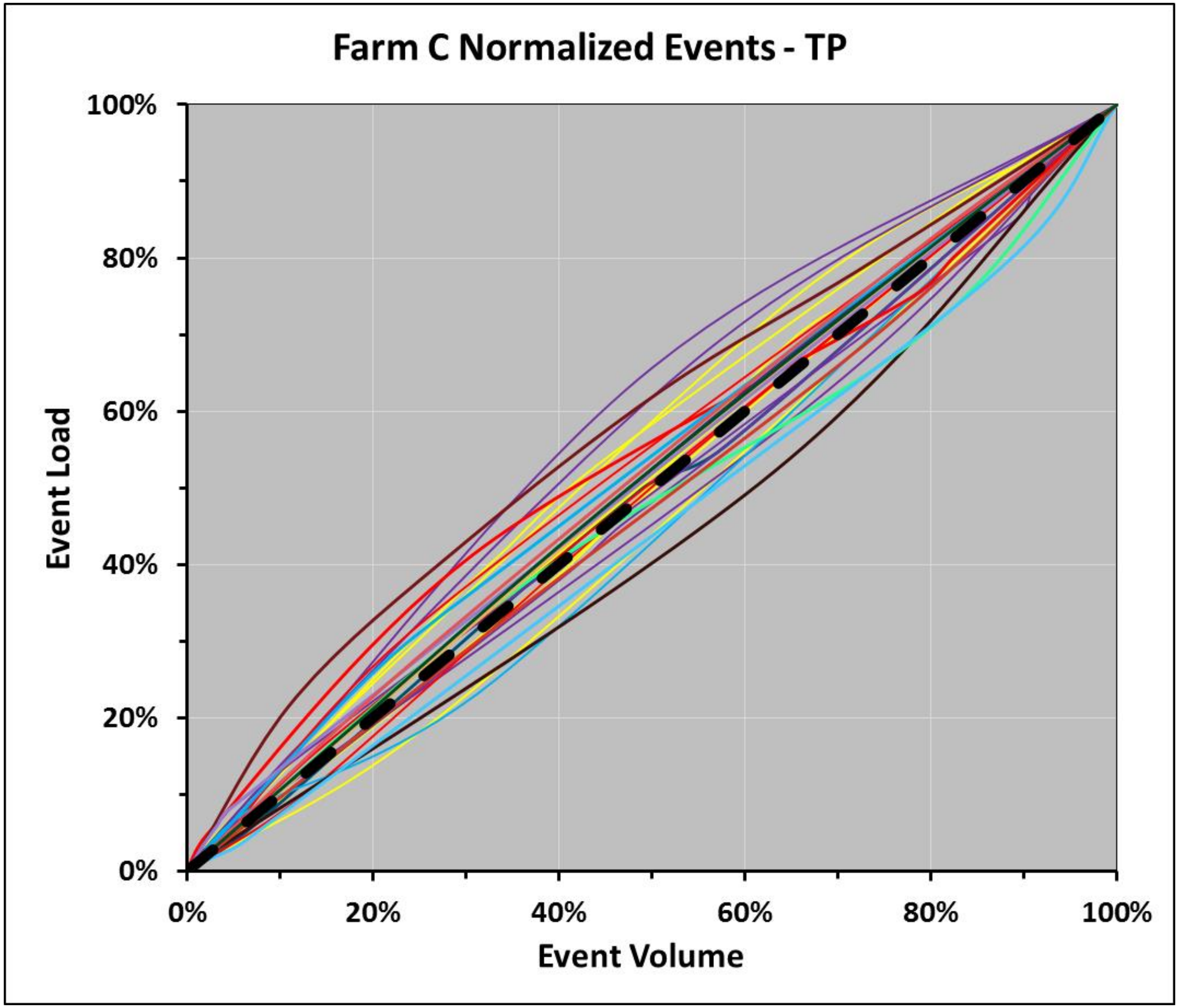
Normalized Phosphorus Data



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? 1st Flush ?

First flush prevalence compared to urban definitions (all farm data combined):

Strict (80/30)[a]		Moderate (40/20)[b]	
TP	**TKN**	**TP**	**TKN**
0	**0**	**3**	**3**
0%	**0%**	**3%**	**3%**

[a] Bertrand-Krajewski et al (1998)
[b] Deletic (1998)

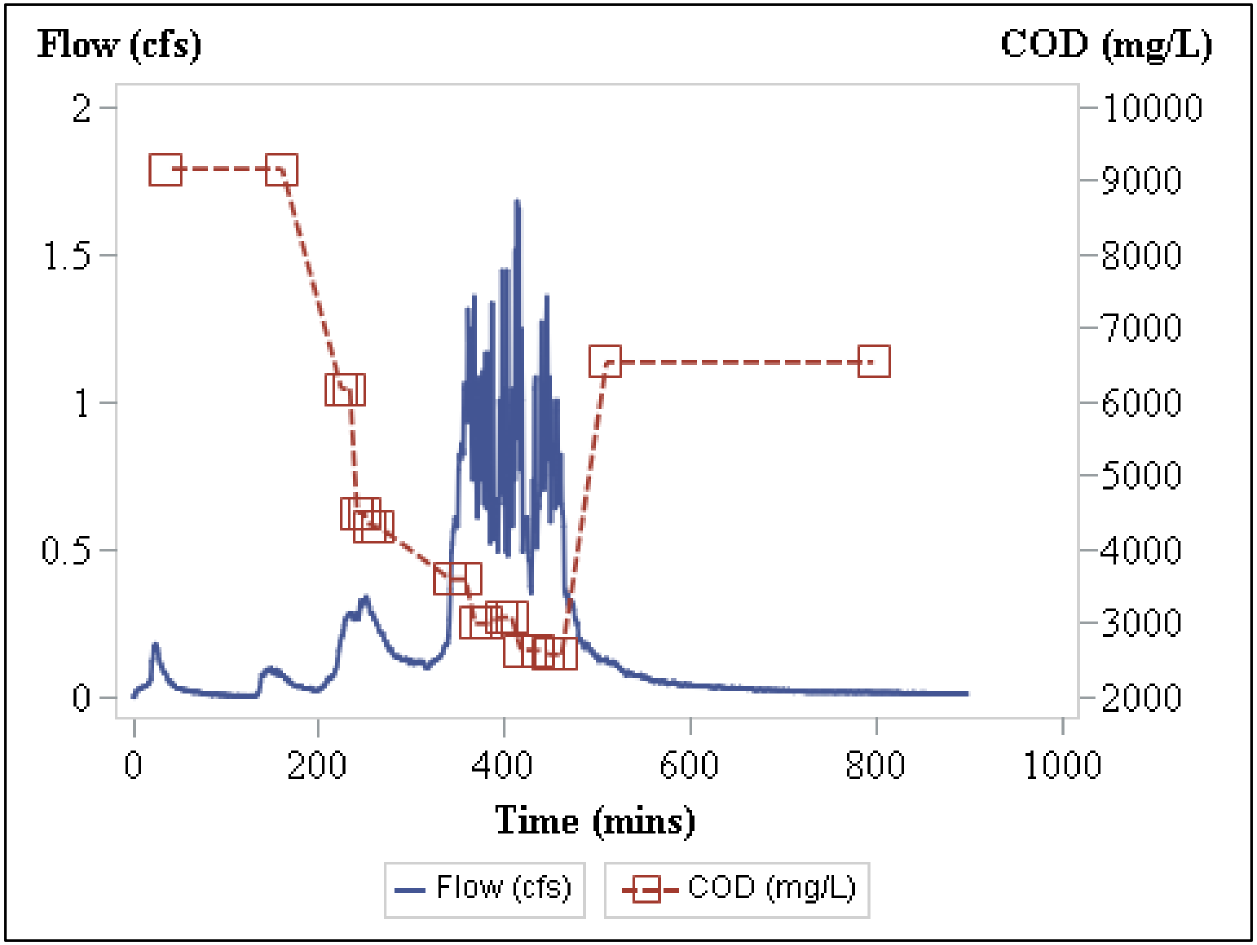
TPn = 116 TKNn = 118

Why doesn't first flush exist?

Runoff concentrations are highly dependent on flow

Influenced by contact and residence time with stored feed, feed litter, and spoilage piles

Concentration-flow Relationship



(Holly PhD thesis, 2015)

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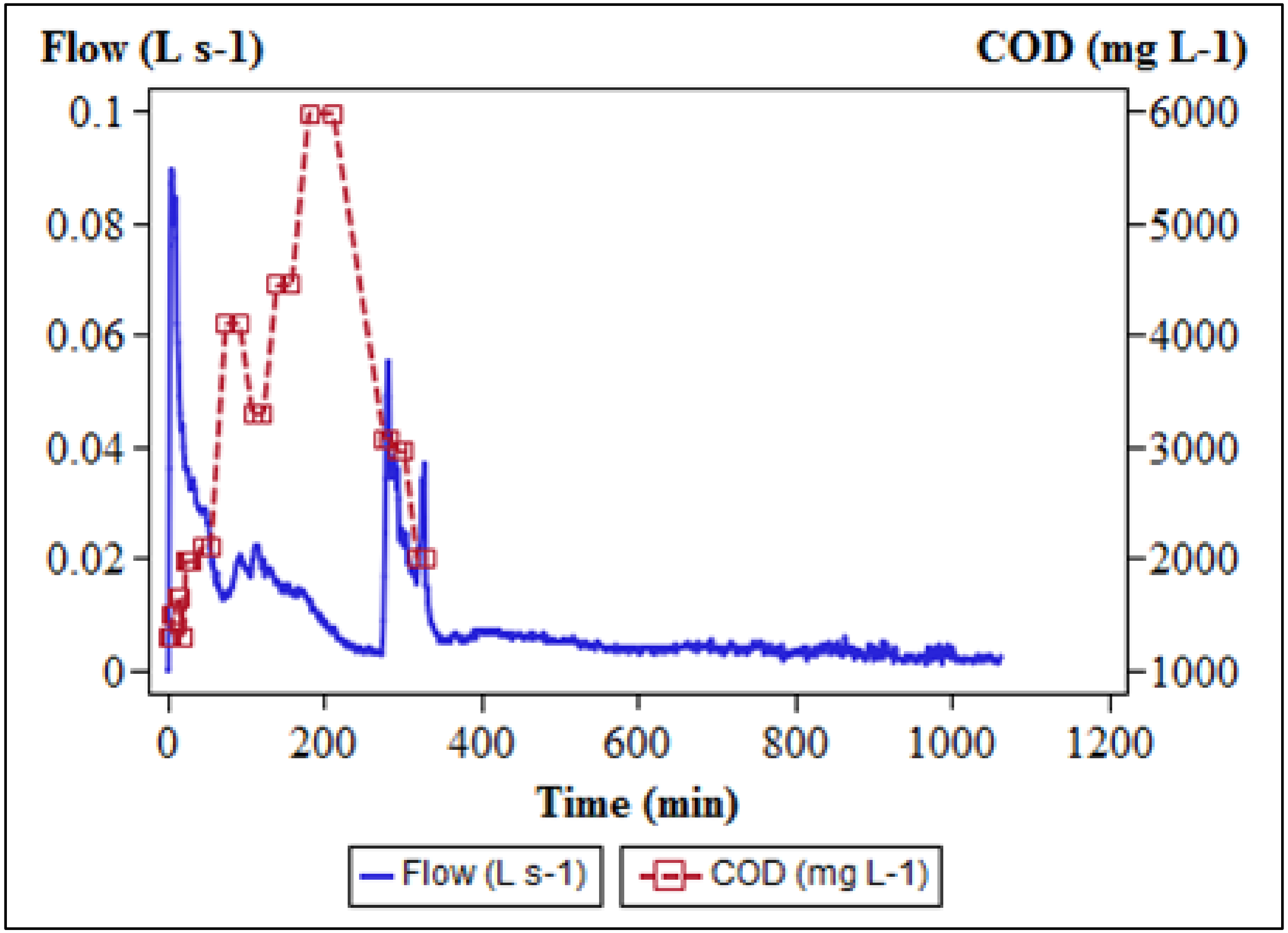

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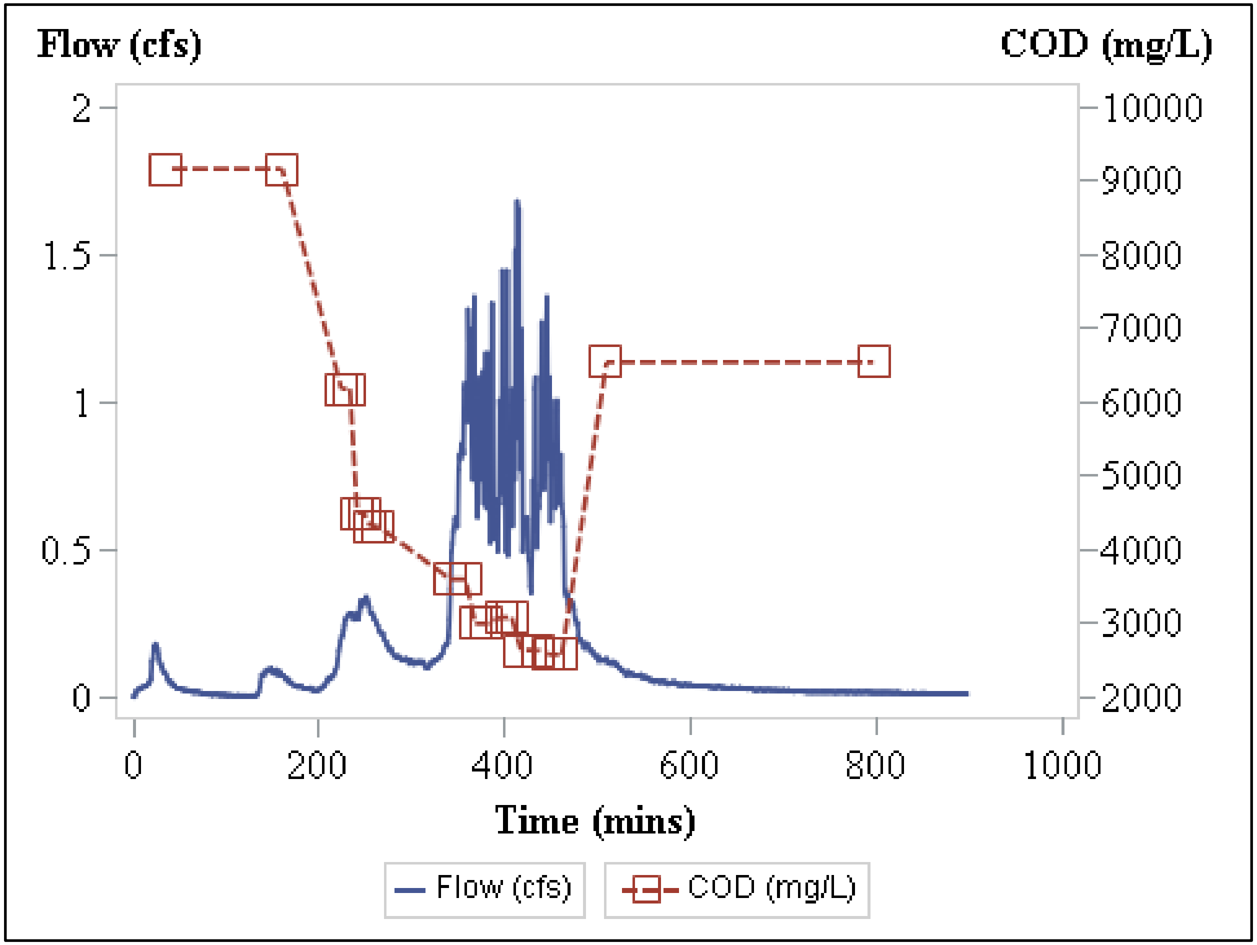

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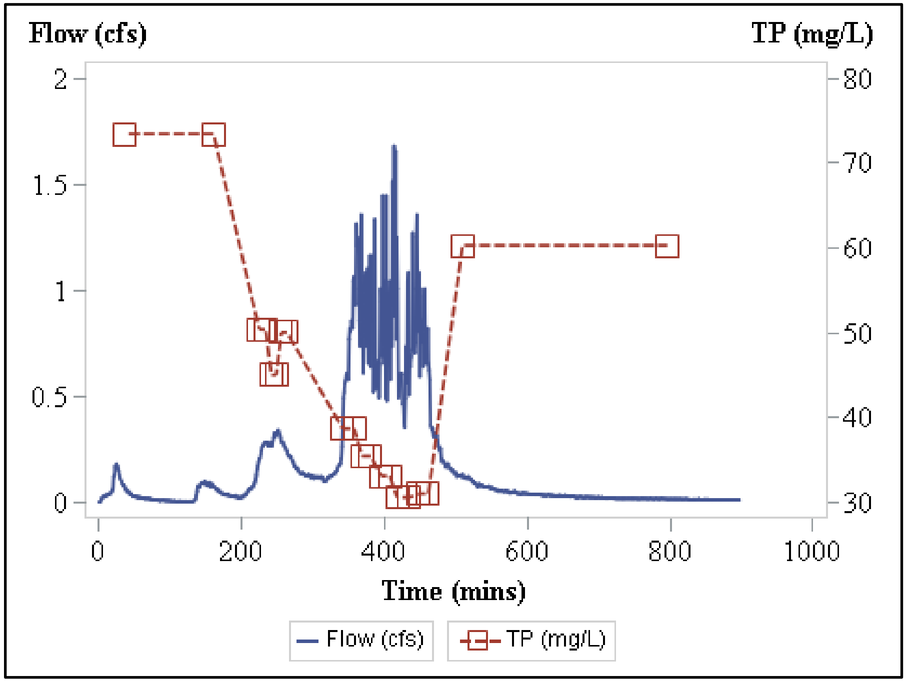
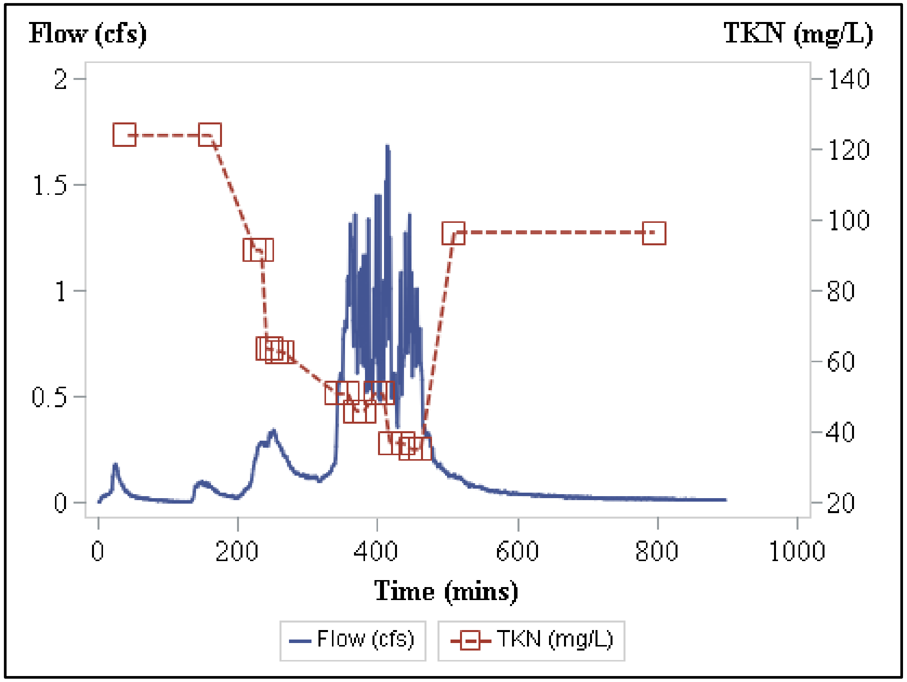
Concentration-flow Relationship

All constituents reacted similarly





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Constituent Correlations

- All constituents (TP, TDP, TKN, Conductivity, COD, TS) were statistically correlated EXCEPT pH which was least correlated and inversely proportional

- This would allow for real-time monitoring of a constituent to determine collection or no collection

Nutrient Speciation

		TP (lbs)	TDP	TKN (lbs)	Ammonia
Farm A	L1	1,204	93%	4,412	37%
	L2	1,106	89%	4,550	24%
Farm B	L3	283	91%	1,029	32%
	L4	1,480	85%	5,893	23%
Farm C	L5	13	88%	78	28%
	L6	71	87%	374	23%

Annual Loading

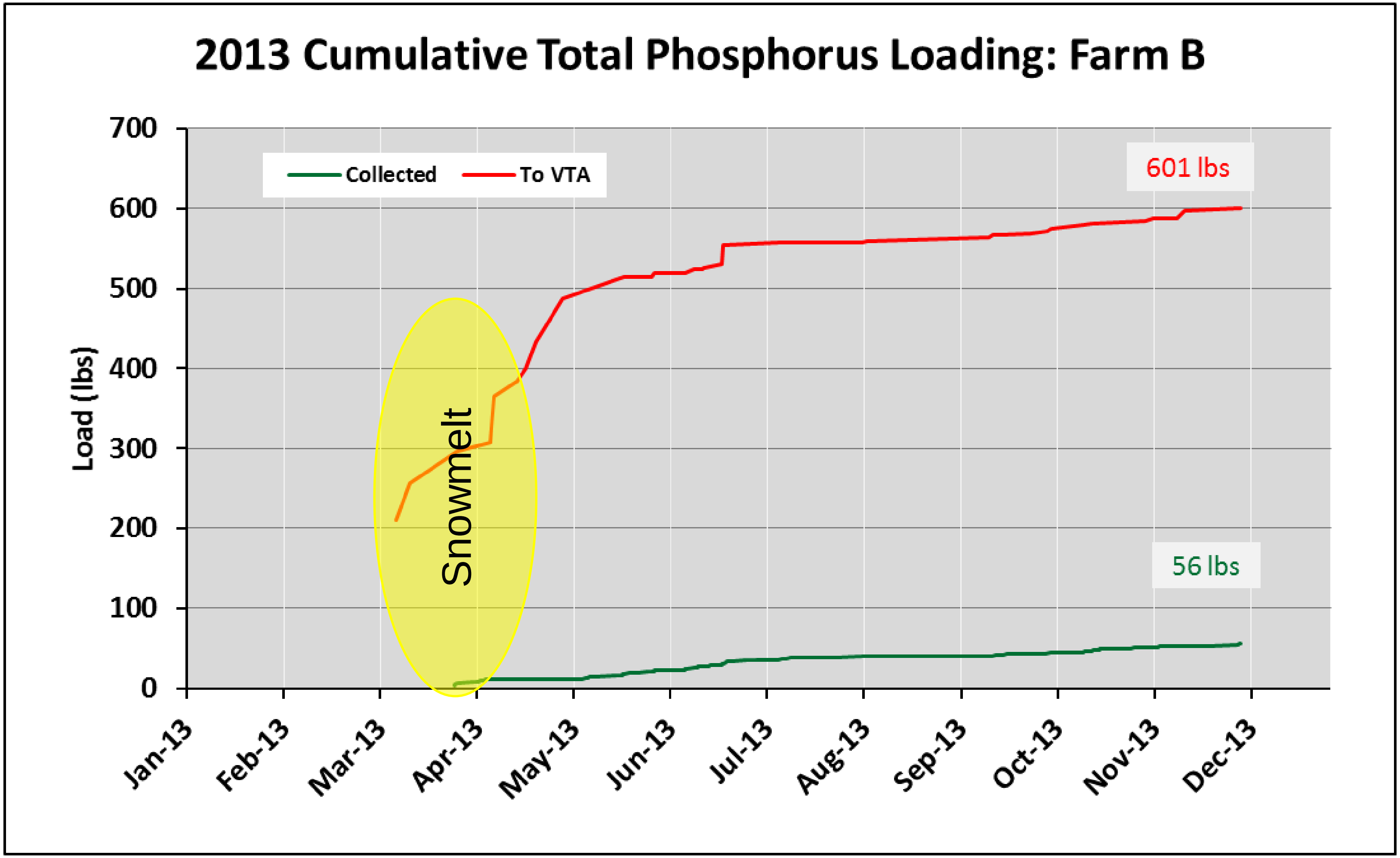
Investigated

- Timing of loading
- Load collected vs. load to VTA
- Volume collected vs. load collected

Seasonality and a few events

- Snowmelt
- Big rains
- Filling

Total P Loading



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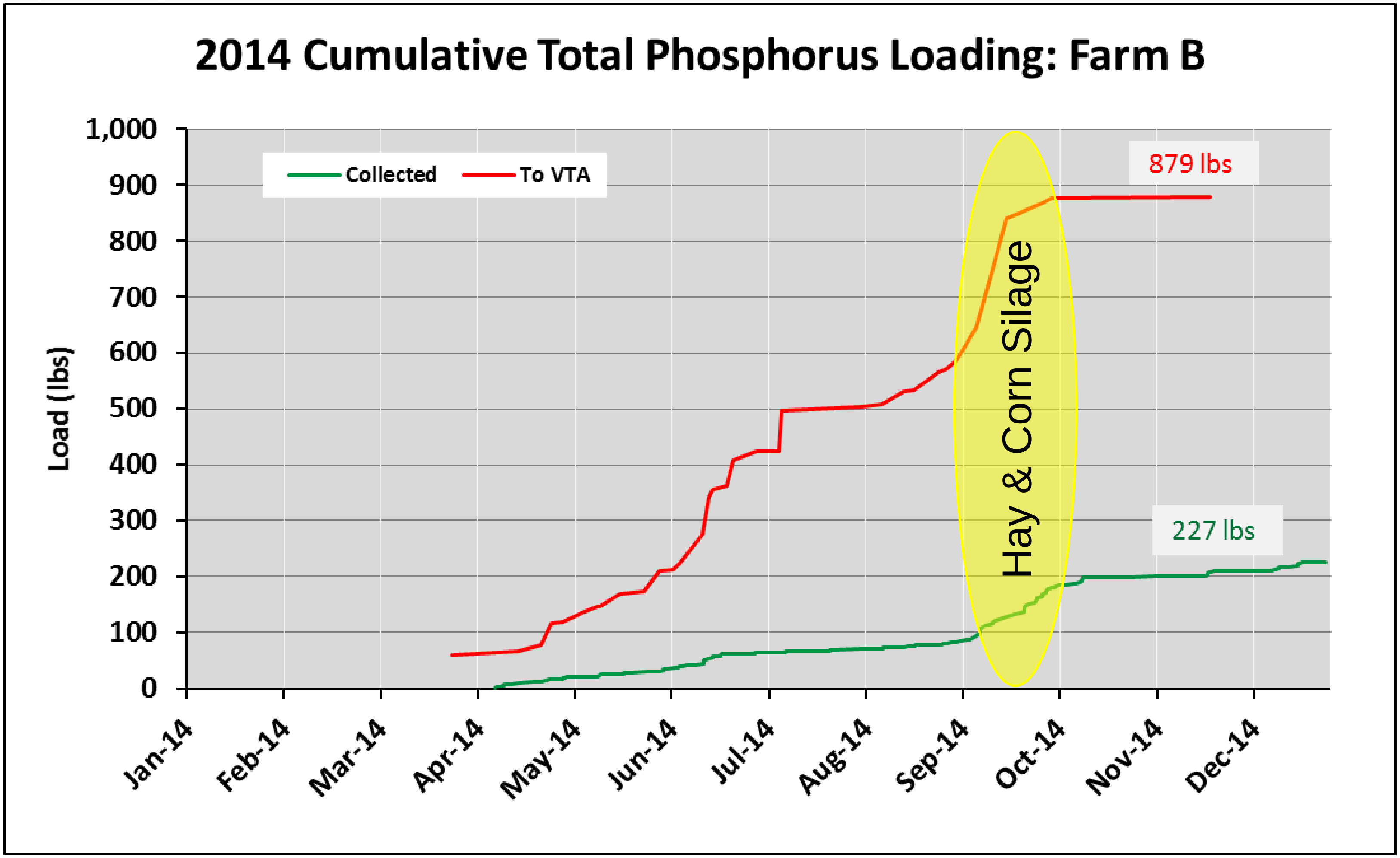
Total P Loading



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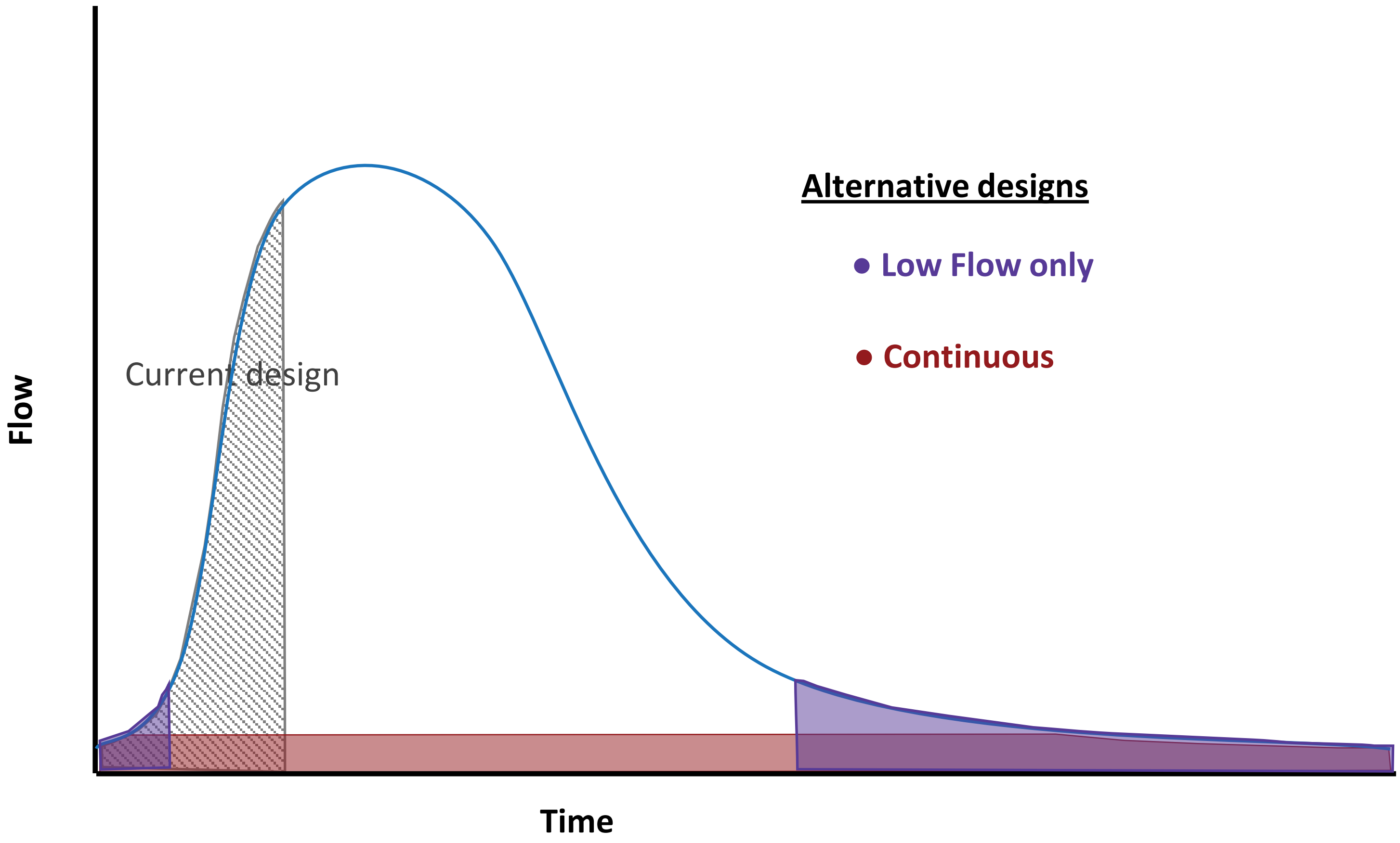
Design Concepts



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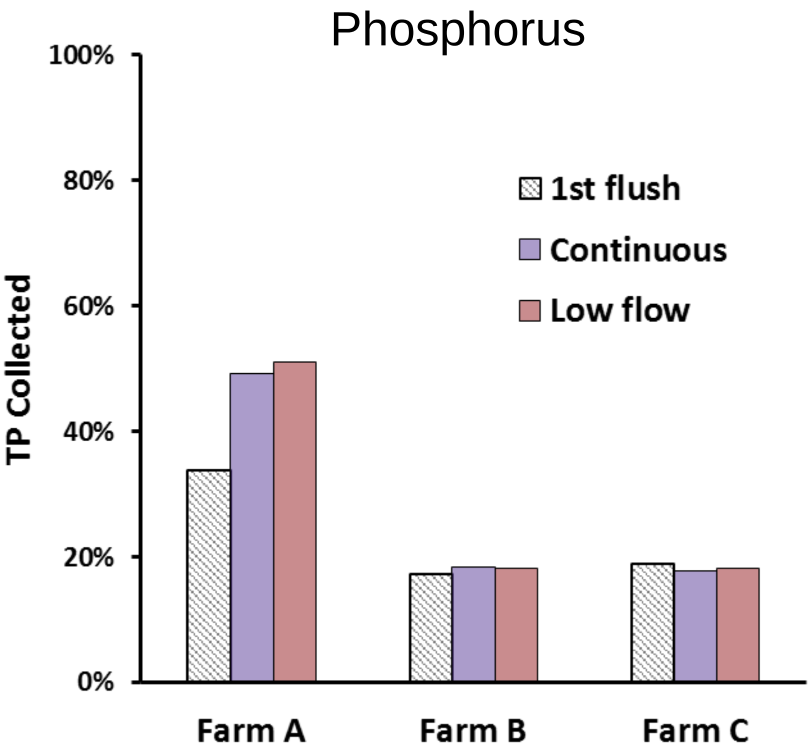
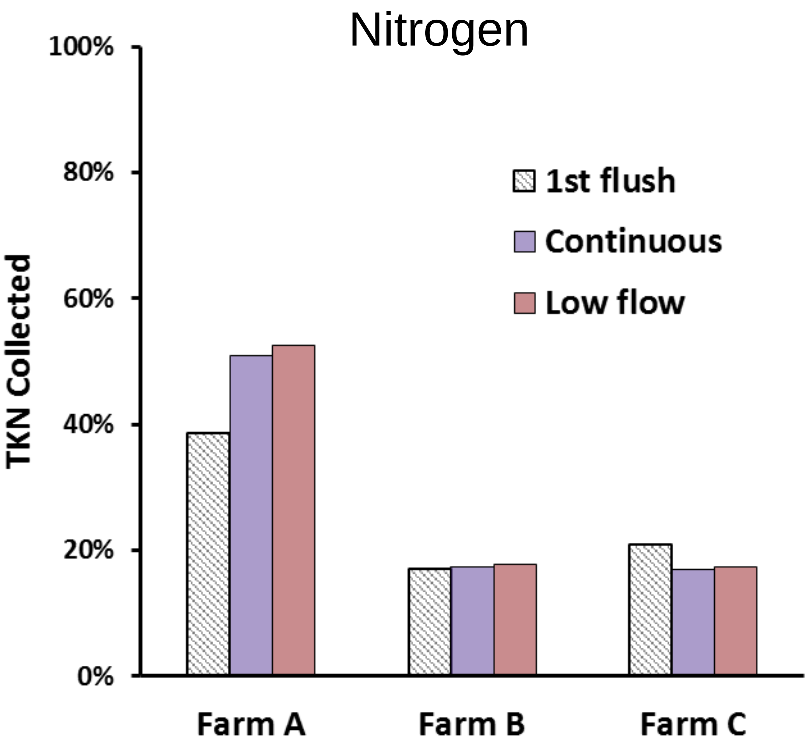
Collection Design Comparisons





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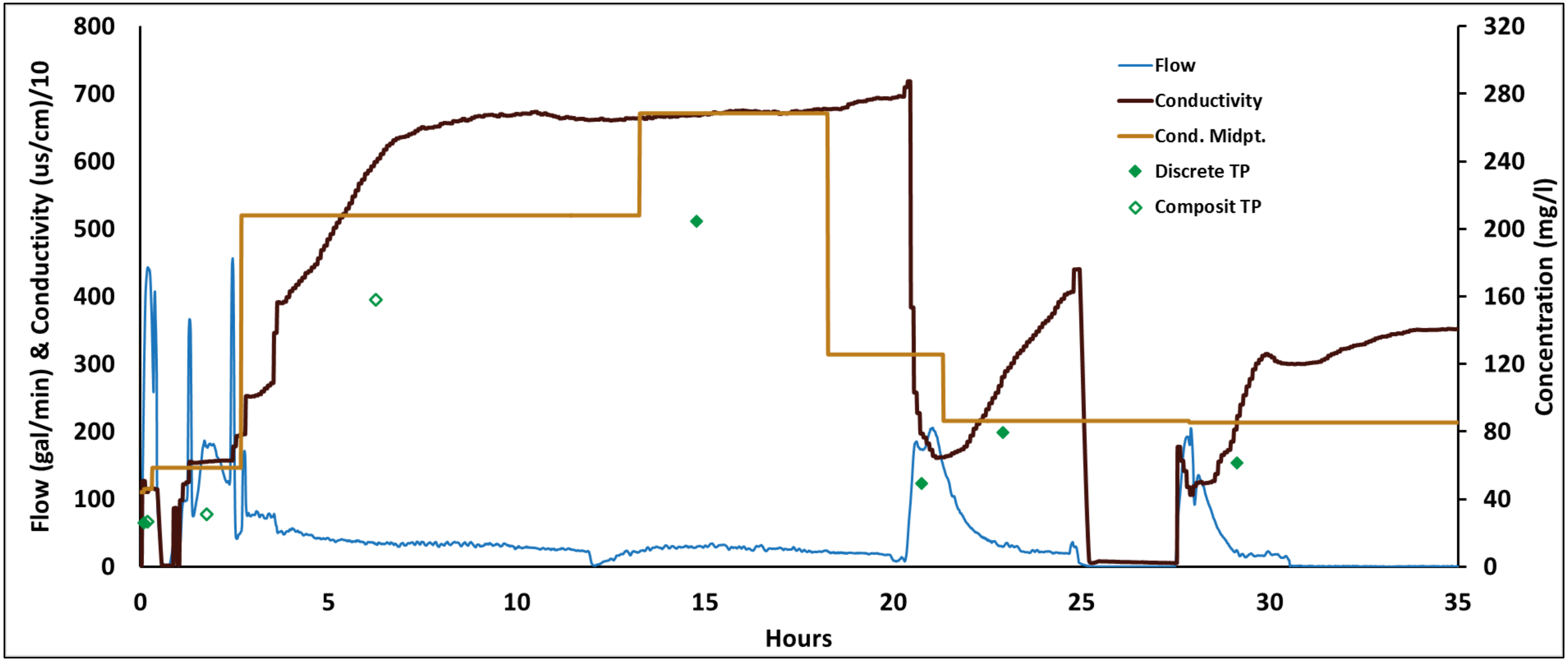
Conductivity Metering



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Collection Design Recommendations

- **First flush rarely exists!**
  - Not the greatest load per volume
  - Collect low flow only
  - Or continuous throughout
- Additional collection within 2 weeks of filling

Minimizing Runoff Concentrations

- **Protect** from water
  - – Cover when filling if rain is forecast
  - – Cover/wrap side walls
  - – Cover and seal edges
  - – Divert clean water away
  - – Minimize exposure when feeding
- **Clean** pad (remove litter) particularly if rain event is forecast
- **Cover** spoilage and litter piles until removal

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Litter and Spoilage

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Ineffective covering

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Key Filter Strip Design Components

- Spreader at point of discharge to filter strip

- Ensure even application across filter strip
  - Irrigation pods
  - Grade evenly (difficult to achieve, need to supervise)
  - Rock checks for spreading
    - Impermeable membrane
    - 2-4 inch round stone
    - Every 100 feet of length

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Spreader at Discharge

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Ineffective Rock Check

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To be continued…

Other analysis being conducted

- Recommended loading: filter strips (Larson)
- Timing and variation of constituent loss
- Effect of feed volume and area covered

Study reports

- Technical report (March)
- Fact sheets (April)
- Extension publications (December)

Thank You!

Questions/Comments

http://www.uwdiscoveryfarms.org

Eric Cooley
Mobile: (608) 235-5259
etcooley@wisc.edu

Engineering/Design:
Dr. Becky Larson
(608) 890-3171
ralarson2@wisc.edu